LARS Contract Report 022681

E83-10150
NASA-CR-167793

(E83-10150) EVALUATION OF SLAR AND THEMATIC MAPPER MSS DATA FOR FOREST COVER MAPPING USING COMPUTER-AIDED ANALYSIS TECHNIQUES Quarterly Progress Report, 1 Dec. 1980 - 28 Feb. 1981 (Purdue Univ.) 21 p HC A02/MF A01 G3/43

N83-16825

Unclas
00150

Quarterly Progress Report

Evaluation of SLAR and Thematic Mapper MSS Data for Forest Cover Mapping Using Computer-Aided Analysis Techniques

Contract No. NAS 9-15889

Reporting Period: December 1, 1980 - February 28, 1981

Submitted to: Exploratory Investigations Branch
NASA Lyndon B. Johnson Space Center

Prepared by: Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

Technical Monitor: Mr. Norman Hatcher
NASA Mail Code SF5
Exploratory Investigations Branch
Houston, Texas 77058

Principal Investigator: Dr. Roger M. Hoffer
Ecosystems Program Leader
LARS/Purdue University
West Lafayette, Indiana 47906

Original photography may be purchased from EROS Data Center
Sioux Falls, SD 57198

TABLE OF CONTENTS

	Page
I. Activities of the Past Quarter	1
A. Spectral Data Analysis Work	1
B. Digitization of SAR Data	2
C. Reformatting of SAR Data	3
D. Qualitative Interpretation of Radar Imagery	5
E. Reformatting and Rectification of August, 1980 MSS Data	6
F. Spatial Resolution Analysis	8
II. Problems Encountered	12
III. Personnel Status	15
Appendix A -- Geometric Adjustment	17

I. ACTIVITIES OF THE PAST QUARTER

A. Spectral Data Analysis Work

During the past several months, much of the emphasis of this investigation was directed at the evaluation of the four different spatial resolutions (15m, 30m, 45m, and 80m) of the NS-001 MSS data (see Quarterly Progress Report: September 1, 1980 - November 30, 1980). Having completed that phase of the work, the emphasis will now be placed upon the wavelength band evaluation, using the training and test data sets for CAM1S from both the May 2, 1979 and August 29, 1980 NS-001 MSS data, geometrically adjusted to 30 meter (Thematic Mapper) resolution. The COMTAL/Vision One/20 display device used for previous training and test field selection is again being used for the final selection of the remaining training and test fields.

In the earlier phases of this investigation, the test data sets were based upon statistically defined individual pixels. However, this approach was found to be very expensive in terms of both analyst time and computer time (display unit) and even then only relatively small numbers of pixels were defined for many of the cover types involved. Therefore, in this next phase of the project, a new approach which we evaluated in terms of relative advantages and limitations, will be implemented. The previous method utilized a test sample grid system based upon the smallest number for which all four resolutions provided a common denominator. (see Quarterly Progress Report: June 1, 1980 - August 31, 1980). However, the new method will utilize a test sample grid based upon an average cover-type field-or-stand size, since only

the 30 meter data will be evaluated and, further, since this will allow a greater absolute number of test pixels per cover class to be chosen.

Due to system complications with the operation of the COMTAL device, current selection of both the training and test fields has been delayed. This problem should be resolved shortly at which time the remainder of the test and training fields will be defined.

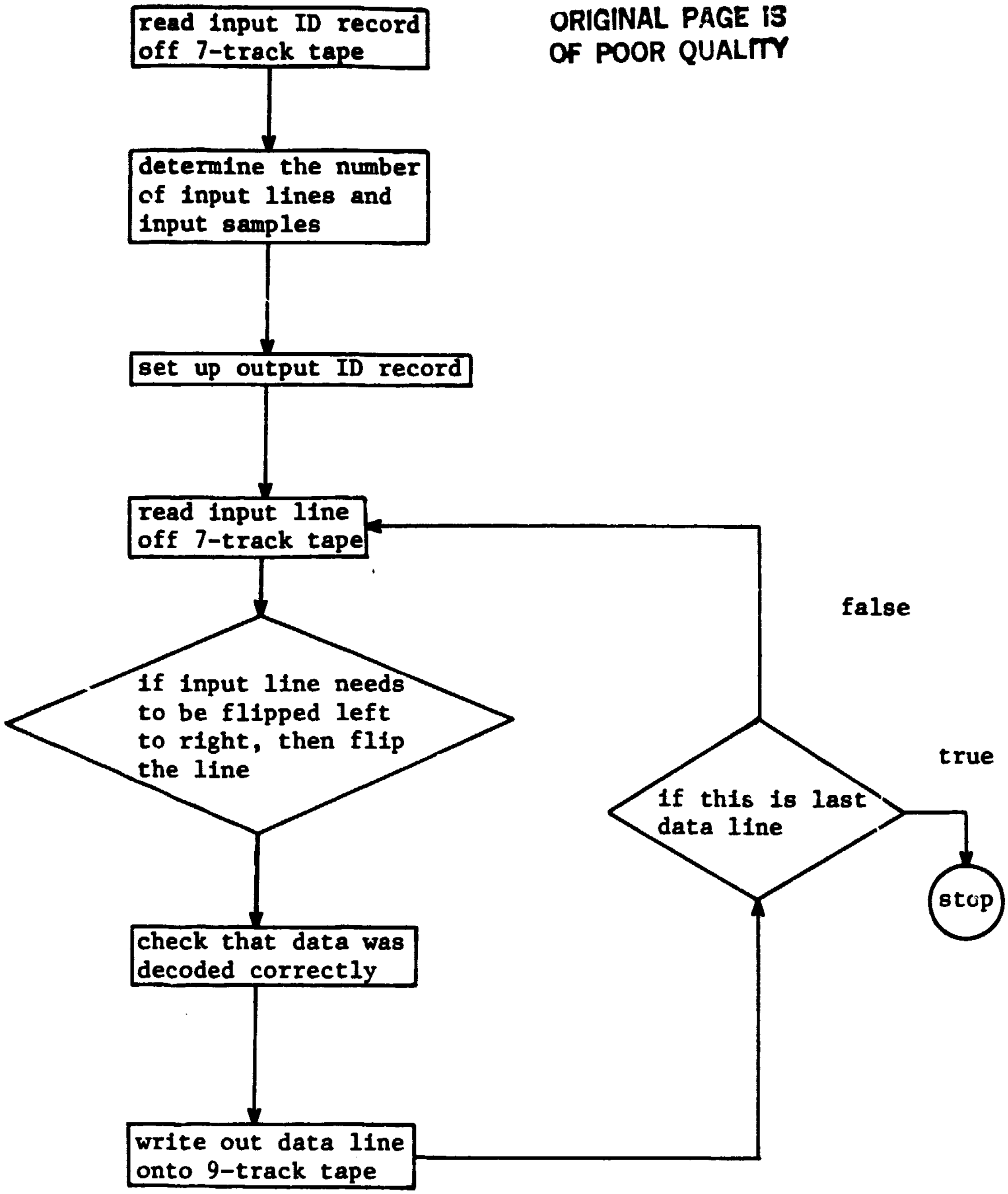
B. Digitization of SAR Data

The digitization of both the HH and HV polarization images (as defined by the parameters given in the previous Quarterly: September 1, 1980 - November 30, 1980) was completed by the Lockheed Corporation at the Johnson Space Center.

The tapes containing the digitized data arrived at LARS on January 12, 1981. Two sets of tapes were received: two 7-track tapes and two 9-track tapes. Both sets of tapes contained the digital data of the different polarizations on separate tapes (i.e., the 7-track set contained one tape of the HH polarization and one tape of the HV polarization). The 7-track tapes were produced directly from the digitization process of the radar images. The data on the 9-track tapes were constructed from the 7-track tapes for convenience in reformatting the data into a compatible LARSYS format, since all LARSYS routines require the data to be on 9-track tapes.

C. Reformatting of SAR Data

The reformatting of the SAR data on the 9-track tapes was not successful, as the tapes did not contain any meaningful data. The program used at JSC to transfer the data from the 7-track tapes to the 9-track tapes apparently had not functioned properly, so the 7-track tapes were copied onto 9-track tapes at LARS. The LARSYS programs were modified and a new program written to enable the digitized SAR data to be reformatted into a LARSYS format. The following flowchart outlines the program used to reformat the data:



Flowchart of steps taken to convert the SAR data to LARSYS format.

The program was run once for each 7-track input tape producing a one-channel LARSYS run each time. The two one-channel runs were then combined to produce a single run containing two channels of information. Table 1 summarizes the ID information of the final reformatted tape.

Table 1. ID information of reformatted SAR data tape.

Run Number	80000500
Tape Number	5282
File Number	1
Lines of Data	2921
Data Samples per Channel per line	696
Number of Channels*	2

*Channel 1 is HH polarization - Channel 2 is HV polarization

D. Qualitative Interpretation of Radar Imagery

A qualitative interpretation of the radar imagery is currently being pursued. The analysis consists of identifying the following major cover types: water, urban, agriculture (bare soil, pasture, and row crops), and forest (coniferous, deciduous, mixed, and clearcut). The analysis of the forest cover type has been further broken down to include species composition and characteristics. Ground truth

information has identified the following forest species to be present: loblolly pine, red maple, sugar maple, sweetgum, oak, pecan, sycamore, ash, hickory, poplar, and horse chestnut. An attempt will be made to determine which of these species can be identified on the imagery by age and stand density. The results of this interpretation will be used for identifying possible cover type classes, for producing a classification map to aid in the evaluation of the numerical classification of the radar data, and for developing an interpretation key for the radar imagery.

E. Reformatting and Rectification of August, 1980 MSS Data

The reformatting of the August, 1980 MSS data into LARSYS format has been successfully completed. Table 2 gives the computer listing of the ID record for the reformated data tape.

Table 2. ID record for the reformatted data tape of the August 29, 1980 MSS flight.

LARS FORM - 170

DATA STORAGE TAPE FILE

RUN NUMBER.................. 80000200	FLIGHTLINE ID.......... 15 CAMDEN,S.C.
DATE TAPE GENERATED..... JAN 20,1981	DATE DATA TAKEN.............. 8/29/80
TAPE NUMBER..................... 5246	TIME DATA TAKEN............ 1530 HOURS
FILE NUMBER...................... 1	PLATFORM ALTITUDE......... 21000 FEET
LINES OF DATA.................. 2370	GROUND HEADING............ 182 DEGREES
SECONDS OF DATA............... 0.0	FIELD OF VIEW........... 0.0 RADIANS
MILES OF DATA................. 0.0	DATA SAMPLES PER CHANNEL PER LINE 844
LINE RATE........... 0.0 LINES/SEC	SAMPLE RATE........ 0.0 MILLIRADIANS
FRAME CENTER LATITUDE....... 34.50	FRAME CENTER LONGITUDE......... 80.62

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.45	0.52	(2)	0.52	0.60	(3)	0.63	0.69
(4)	0.76	0.90	(5)	1.00	1.30	(6)	1.55	1.75
(7)	2.08	2.35	(8)	10.40	12.50	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

MP-316

The geometric adjustment of the August, 1980 MSS data has been successfully completed. The reasons for the adjustment and the flowchart of the program used were given in the second quarterly report (Reporting period: September 1, 1979 - November 30, 1979) and have been attached in the appendix (Appendix pp. 17-18) for reference convenience. Due to a difference in flying height between the 1979 and 1980 data sets (1979 - 20,000 ft. and 1980 - 21,000 ft.), a scan angle of 33.7^{o} from nadir was used to truncate the data rather than using an angle of 35^{o}. This would allow approximately the same area on the ground to be represented by both data sets. Figures 1 and 2 are Varian images showing the geometric characteristics of the original "raw" data set and the adjusted data set respectively.

F. Spatial Resolution Analysis

Work on the analysis of the four spatial resolution data sets (15m x 15m, 30m x 30m, 45m x 45m, and 60m x 75m) was completed during the past quarter, and is in the process of being documented. Many of the major results of this work were presented at the NFAP Research Review in Houston on January 7. The paper, by R. M. Hoffer and R. S. Latty, was entitled "Multisensor Analysis of Forest Cover in South Carolina," and was presented by Roger Hoffer.

In addition to the information described in the last quarterly progress report, this work can be synopsized in part, by the following conclusions statements:

1) The degree to which the probability density functions actually

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Figure 1. Varian imagery of the "raw" August, 1980 MSS data set prior to any manipulations (channel 5, 1.00 - 1.30 μm).

Figure 2. Varian imagery of the geometrically adjusted August, 1980 MSS data set (channel 5, 1.00 - 1.30 μm).

represent the spectral variability of each of the cover classes of interest is a more important determinant of classification performance than either the spatial resolution of the data or the classifier employed (over the range of resolutions and classifiers employed).

2) Higher overall classification accuracies were obtained with the use of lower spatial resolution data.

3) Higher classification accuracies using lower spatial resolution data were obtained for cover classes which had a relatively large degree of spectral variability across adjacent pixels (eg., old age hardwood, second growth hardwood, clearcut and urban) as opposed to those cover classes which had relatively low levels of spectral variability across adjacent pixels (eg., soil, crops, pasture, and water).

4) Cover classes with very distinct spectral characteristics, in spite of relatively high levels of spectral variability across adjacent pixels, can be classified with a high degree of accuracy regardless of the spatial resolution of the data employed (over the range of resolutions examined).

5) Higher spatial resolution data will provide higher classification accuracies in areas where the cover classes occupy relatively small contiguous areas (i.e., where "field" sizes are small).

6) Provided the probability density functions represent the spectral variability associated with each respective cover

class, higher overall classification accuracies can be obtained with the use of the *SECHO than with the per-point GML classifier.

7) Greater improvements in overall classification accuracies can be achieved with the *SECHO versus the per-point GML classifier for areas where the "field" sizes are large as opposed to areas where the "field" sizes are relatively small.

8) Higher classification accuracies were obtained for cover classes associated with relatively high degrees of spectral variability (eg., old age hardwood, second growth hardwood, clearcut, and urban) with the *SECHO classifier as compared to the per-point GML classifier when using 30 meter spatial resolution data.

9) Training procedures which are appropriate for data of high spatial resolution are not necessarily well suited for developing training statistics for low spatial resolution data.

II. PROBLEMS ENCOUNTERED

A major problem encountered in this quarter involved the digitized radar imagery. The digitized data of both the HH and HV polarized imagery had very small standard deviations -- 14.4 and 4.39, respectively. Figures 3 and 4 show the computer output of the histograms. Notice that a large number of pixels are concentrated in a few bins (which is indicated by the small standard deviations). Due to the spread of the data being so tight, the classification algorithms would not be as effective as would usually be expected. Because of

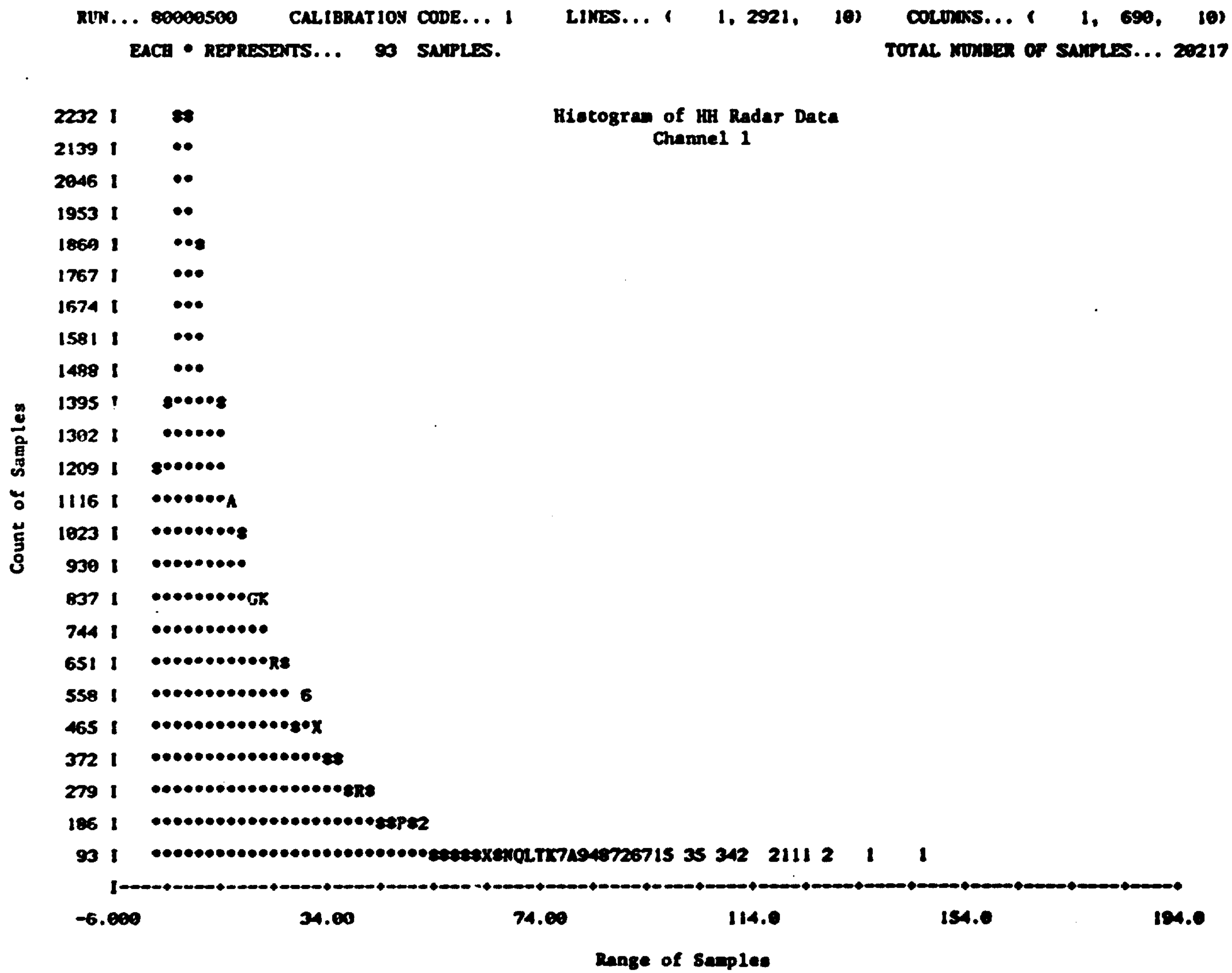


Figure 3. Computer output histogram of digitized radar data (HH polarization).

```
RUN... 80000500     CALIBRATION CODE... 1     LINES... (   1, 2921,   10)    COLUMNS... (    1,  690,   10)
     EACH * REPRESENTS...  282  SAMPLES.                                    TOTAL NUMBER OF SAMPLES... 20217

                                           Histogram of HV Radar Data
                                                    Channel 2
         6768 I           $
         6486 I           *
         6204 I           *
         5922 I           *
         5640 I           *
         5358 I           *
         5076 I           *
         4794 I           *$
         4512 I           **
         4230 I           **
         3948 I           **
         3666 I           **
         3384 I          $**
Count    3102 I          ***
 of      2820 I          ***
Samples  2538 I          ***P
         2256 I          ****
         1974 I          ****
         1692 I          ****
         1410 I          ****$
         1128 I          *****
          846 I          *****$
          564 I          Z******$
          282 I          ********$$$$$THF9626443 131 1 1   1  1 11            1          1
              I----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
            -19.00              21.00              61.00              101.0              141.0              181.0

                                               Range of Samples
```

Figure 4. Computer output histogram of digitized radar data (HV polarization).

this problem, arrangements have been made with Lockheed personnel at JSC to redigitize the radar imagery. It is anticipated that this redigitization will take place during the first week of March, and the redigitized data should be received at LARS during the week of March 9-13.

III. PERSONNEL STATUS

The following personnel committed the respective percentages of time to the project during the past quarter:

Name	Position	Ave. Monthly Effort (%)
Bartolucci, L.	Prof. Research Analyst	03
Brown, M.	Secretary	04
Dean, Ellen	Research Associate	50
Frazee, Mike	Research Assistant	30
Hoffer, Roger	Principal Investigator	35
Knowlton, Doug	Research Associate	50
Latty, Rick	Research Associate	25
Prather, Brenda	Secretary	50

IV. ANTICIPATED ACCOMPLISHMENTS

The following are the anticipated accomplishments for the forthcoming quarter (March 1 - May 31, 1981):

1) Redigitization of the SAR data by JSC.

2) Reformatting and overlay of the HH and HV polarization by LARS Data Handling personnel.

3) Assessment of the radiometric variance problem within scan lines of the 1980 MSS data and radiometric adjustment of the data if deemed necessary and reasonable.

4) Continuation of the analysis of the spectral characteristics of the 1979 TMS data.

APPENDIX A

A. Geometric Adjustment

The evaluation of the spatial characteristics of the data was completed. A program was developed to reduce the spatial distortions resulting from variable viewing distance, and geometrically adjusted data sets were generated.

The objective of the geometric adjustment efforts were: 1) to produce a data set which corresponded geometrically to aerial photography and U.S.G.S. maps of the area, to facilitate identifying training and test areas, and 2) to produce a data set which would provide accurate area estimates from pixel summations. The criteria used in identifying the acceptable level of geometric correction were: 1) consistency of scale in each dimension everywhere in the data set, and 2) equivalency of scale between the two dimensions.

The general features of the routine that was developed for this purpose are:

1) The routine is based on a model which defines the location and dimension of each pixel, for each line in the data set.
2) The model is purely deterministic. There was no attempt made to compensate for stochastic variations in the geometry (i.e., image characteristics resulting from random roll, pitch, yaw, or change in altitude of the aircraft).
3) The data set was truncated at the $\pm$ 35^{o} viewing angle. (See radiometric adjustment for discussion.)
4) No data within the set defined by the bounding viewing angles (i.e., within $\pm$ 35^{o}), was omitted.

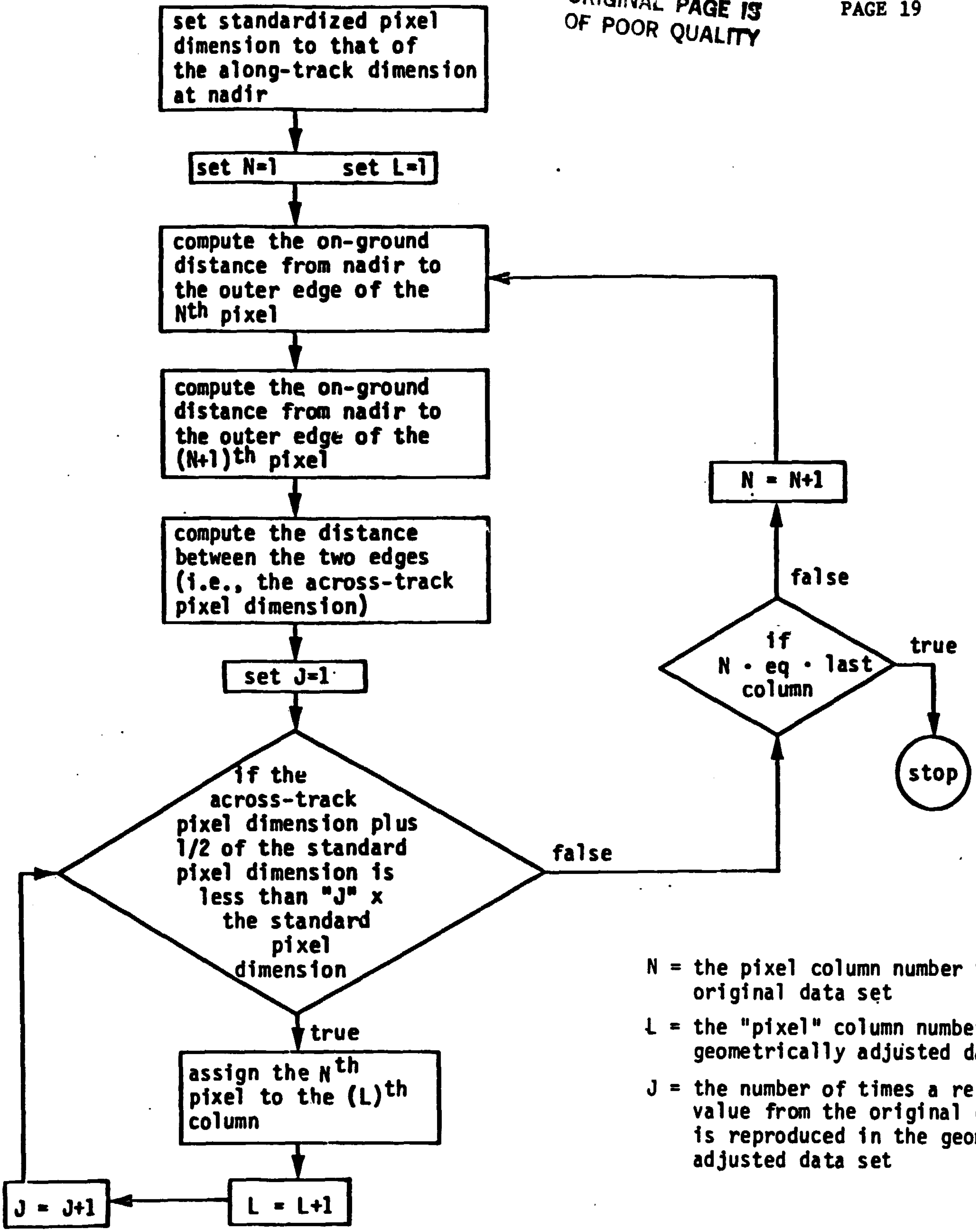
The along-track scale of the pixel at "nadir" was determined by locating control points on the image and a 1:62,500 U.S.G.S. map, computing the "ground" distance between the points along the component parallel to the flight line (perpendicular to the scan lines), and dividing by the number of scan lines between the two points. The along-track distance per scan line was approximately 7.6 meters. The 2.5 mrad IFOV of the scanner and the 20,000 ft. (6,096 meters) flight altitude would result in a 15.24 meter (50 ft.) scan line width at nadir, which indicates there was an over-scan of approximately 2. A standardized "pixel" dimension of 15.3 x 15.3 meters was chosen due to the spatial characteristics of the data.

The geometric adjustment process is basically a repetitive reassignment of the existing data values to integer multiples of data addresses. The value of the integer multiple expresses the number of "standardized pixels" which will fit into each actual pixel, due to the particular dimensions resulting from its angular displacement from nadir. Figure 1 is a flowchart describing the procedure employed for each channel, for each line of data. The procedure clarifies the fact that data cells in the resulting data set no longer represent pixels on a one-to-one basis. A pixel is now represented by some integer multiple of data cells.

Figure 2* is a Varian image showing the geometric and radiometric characteristics of the original "raw" data set. The vertical line represents the nadir column. Figure 3 was generated from the geometrically adjusted data set.[1/] It should be apparent by comparing Figures 2 and 3, that visually separable units become increasingly compressed in the across-track dimension with increasing distance from the nadir column in the original data set image as compared to the adjusted data set image.

The consistency of scale in each dimension and the equivalency of scale between dimensions (i.e., along-track and across-track) was evaluated by superimposing control points located on a 1:62,500 U.S.G.S. map onto the adjusted imagery using a Zoom Transfer Scope. The coincidence of all control points indicated that the acceptance criterion was met. Geometrically adjusted data sets were then generated for all areas in the study site.

*Note: For Figures 2 and 3 see the quarterly report for the Reporting Period September 1, 1979 - November 30, 1979.



N = the pixel column number in the original data set

L = the "pixel" column number in the geometrically adjusted data set

J = the number of times a reflectance value from the original data set is reproduced in the geometrically adjusted data set

Figure 1. Flowchart of steps taken to geometrically adjust a data set from the NS-001 scanner. This removes, or reduces, differences in pixel widths as a function of changing viewing angles.